system as this is adopted in reading all large circles. But when it is a question of measuring smaller arcs, the micrometer may be used with the telescope itself, its wires appearing with the image of the object in the field of view.

A description of an experiment will perhaps convey a better idea of what can be done in this way. Fig. 15 represents the arrangement. The condensing lens of the lantern having been removed, the light is allowed to impinge upon a lens, A, placed at a slight distance from the lantern. Its action on the light causes a reversed image of the poles to be produced in the air. The light coming from this image is then made to pass through another lens, B; the reversal is corrected, and a magnified image of the poles of the electric arc is thrown upon the screen. The first lens which forms the image may be regarded as the object-glass of a telescope, whilst the other lens which throws the magnified image upon the screen is the counterpart of the telescope's eyepiece. Now if at C, where the image is formed in air, the micrometer wires are placed, they, with the image of the poles, will appear magnified on the screen.

In this manner bodies appear with the wires in the field of vision of the telescope, and their diameters and the dimensions of different parts of them may be most accurately determined. Up to the present time we have been concerned simply with accurately determining the positions occupied by the various bodies which people space. But with this micrometer in the field of view of the telescope something more than this may be done. We may now determine some measurements upon the bodies whose positions alone we have been considering up to now. For instance, the image of a planet may be grasped by the wires, one wire bounding one limb of the planet, the other wire lying along the other limb. Then, knowing how many complete turns, and 1/100th, and 1/1000th parts of a turn have been given to the head of a screw in order that the wires may be separated through such a distance, and knowing also the value of these divisions in seconds of arc, the diameter of the planet may be measured. In like manner, the heights of lunar mountains may be ascertained by measuring the lengths of the shadows thrown by them. Or it may be a question of the distance between two stars close together. The method is still the same. One star is made to lie along the movable wire, the other is seen on the fixed one, and the distance through which the wires are separated ascertained. Having attained to this, let us bring our inquiry into angular measurement to a close.

In passing, as we shall in the sequel, from the measurement of space to the measurement of time, it will be found that the difficulties have been grappled with very much in the same way. In this measurement of space we began with simple instruments, and only by a slow growth has the modern instrument been arrived at; yet notwithstanding the immense changes that have taken place, the pointer and circle of the old instrument are still represented in the new, whilst the vernier and micrometer, still preeminent, enable a degree of fineness to be attained quite unparalleled in the old days. But in passing from these older instruments, in which the circle was so prominent a feature, and the pointer so small, to the more modern instruments, it will be seen that, although both are still preserved, a great change has taken place. The pointer, represented by the telescope, is the prominent part of the instrument, whilst the circle is hidden away almost out of sight.

J. NORMAN LOCKYER

(*To be continued.*)

TABLE OF DIFFERENT VELOCITIES EXPRESSED IN METRES PER SECOND

THE following table has been drawn up by Mr. James Jackson, Librarian to the Paris Geographical Society :—

	Metres per second.
A man walking 4 kilometres an hour	1·11
,, ,, 5 ,, ,,	1·40
The comet of Halley in aphelion	3·25
A ship going 9 knots an hour (9 × 1852 metres)	4·63
Ordinary wind	from 5 to 6
A ship going 12 knots an hour (12 × 1852 metres)	6·17
A wave 30 metres in magnitude with a depth of 300 metres	6·81
A ship going 17 knots an hour (17 × 1852 metres)	8·75
A fresh breeze	10
A torpedo boat going 21 knots an hour (21 × 1852 metres)	10·80
A race-horse trotting an English mile in 2 min. 14 sec.	12
,, ,, galloping 900 metres a minute	15
An express train running 60 kilometres an hour	16·67
Flight of a falcon, of a carrier pigeon	18
A wave in a tempest at sea	21·85
An express train running 60 English miles an hour (60 × 1609 metres)	26·81
A tempest	from 25 to 30
The transmission of sensation by human nerves	33
A hurricane	40
Flight of one of the swiftest birds	88·90
Velocity of a point on the equator of Mercury	146·87
Propagation of the tide caused by the earthquake of Arica on August 13, 1868 (Arica to Honolulu), according to Hochstetter	227·38
Velocity of a point on the equator of Mars	244
,, sound in the air (+10° C.)	337·20
,, a point on the equator of Venus	454·58
,, ,, ,, the Earth	463
A cannon ball	500
Propagation of the movement of tides (North Pacific Ocean); maximum according to Whewell	922
The moon's revolution round the Earth	1012
Velocity of a point on the equator of Mercury	1034
Revolution of the second satellite of Mars	1157
Concussion of the earthquake of Viège (July 25, 1855); from Turin to Geneva in 126 seconds	1368
Velocity of sound in water (+8°·1 C.)	1435
Revolution of the first satellite of Mars	1833
Velocity of a point on the equator of the Sun	2028
Revolution of the fourth satellite of Uranus	3300
,, ,, eighth ,, Saturn	3738
,, ,, third ,, Uranus	3814
Velocity of a point on the equator of Uranus	3904
Revolution of the satellite of Neptune	4505
,, ,, second satellite of Uranus	4906
,, of Neptune round the Sun	5390
,, of the first satellite of Uranus	5763
,, ,, seventh ,, Saturn	5794
,, ,, sixth ,, ,,	6398
,, of Uranus round the Sun	6730
Proper movement of Vega	7000
Displacement of the sun towards the constellation of Hercules	7642
Revolution of the fourth satellite of Jupiter	8359
,, of Saturn round the Sun	9584
,, of the fifth satellite of Saturn	9741
Velocity of a point on the equator of Saturn	10,541
Revolution of the third satellite of Jupiter	10,869
,, ,, fourth ,, Saturn	11,516
Velocity of a point on the equator of Jupiter	12,491
Revolution of Jupiter round the Sun	12,924
,, of the third satellite of Saturn	13,038
,, ,, second ,, Jupiter	13,999
,, ,, ,, ,, Saturn	14,568
,, ,, first ,, ,,	16,425
,, ,, ,, ,, Jupiter	17,667
,, of Mars round the Sun	23,863
,, of the Earth ,, ,,	29,516
,, of Venus ,, ,,	34,630
Proper movement of Capella	40,000
Revolution of Mercury round the Sun	47,327
Proper movement of Sirius	51,000
Ordinary movements of the solar atmosphere	from 30,000 to 65,000
Proper movement of the 61st of Cygnus	71,600
,, ,, Arcturus	85,000
The comet of Halley in perihelion	393,260
Tempests of the solar atmosphere	402,000
Electricity; a telegraphic submarine wire	4,000,000
,, ,, aërial ,,	36,000,000
Velocity of light	300,400,000

THE BRITISH ASSOCIATION

REPORTS

Report of the Committee on Electric Standards, read by Mr. R. T. Glazebrook.—This comprised an account of the means adopted at the Cavendish Laboratory for comparing resistance coils sent to be tested with the B.A. units.

Report of the Committee on the Harmonic Analysis of the Tides was read by Prof. Adams, who said that the Indian Government were entitled to great gratitude for carrying on tidal observations for many years on a thoroughly scientific system, and he thought they might be held up as an example to our own Government, which was very niggardly in these matters. He suggested that tidal observations should be made on the coast of the English Channel, as there were certain peculiarities in the tide which ought to be investigated.

Report of the Committee appointed to Cooperate with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis was drawn up by Mr. Murray for Prof. Crum Brown. Stations had been established at various points at which observations were made by the observer, Mr. Wragge, half-hourly as he ascended or descended the mountain. Simultaneous observations were made at Fort William. The diurnal curves for pressure, temperature, and humidity have been drawn, and show the insular character of the climate markedly. At the top the degree of saturation and its persistency is important. In 1881 this was a specially marked feature under the approach of numerous cyclones from the Atlantic; in 1882 anti-cyclones prevailed, and there were frequent changes from saturation to extreme dryness—a dryness comparable with that of the Sahara—occurring in very short intervals of time. This extreme dryness was accompanied by a very high temperature. The results are to be analysed shortly by Mr. Buchan for the Scottish Meteorological Society.

Sixteenth Report of the Committee appointed for the Purpose of Investigating the Rate of Increase of Underground Temperature Downwards in various Localities of Dry Land and under Water was read by Mr. J. Glaisher. The observations were made at an artesian well at Southampton, Dolcoath Mine, North Seaton Colliery, Ashton Moss Colliery, and Ashton-under-Lyne. The report concluded by stating that if we assumed 1° in 57·8 feet as the rate for the St. Gothard Tunnel, and also for the Mont Cenis Tunnel, the effect upon the general mean for all places will be to make it 1° F. in 60 feet, instead of 1° F. in 64 feet.

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE

On the Forms of the Sun's Influence on the Magnetism of the Earth, by Prof. Balfour Stewart.—The author endeavoured to show that there are two forms of solar influence:—

A. That which produces the diurnal variation, the range of which is greatest a little after the time of maximum sunspot frequency.

B. That which produces a magnetic change on the earth as a whole; and this, too, acts in such a manner that the intensity of terrestrial magnetism is apparently greatest after a maximum of sunspots.

It is with this second form of influence that the author deals, and he endeavours to show that it leads—

1. To simultaneous increments or decrements of the horizontal force at various states as observed by Broun.
2. To two maxima of horizontal force at the solstices and two minima at the equinoxes, as observed also by Broun.
3. It appears that the strength of solar action, when the sun is favourably disposed with regard to the northern hemisphere (June) is greater than when it is favourably disposed with regard to the southern hemisphere (December), a circumstance which leads to an annual variation.
4. It also appears that it is what has been termed the induction system of the earth that is thus affected by the sun.

On the Heating Power of the Sun's Rays at London and at Kew, by Professors Roscoe and Balfour Stewart.—The observations discussed were made by Campbell's method, in which a spherical glass lens had its focus along the surface of a hemisphere of wood, so that, whenever the sun shone, a portion of the wood was burned. The wooden hemisphere was renewed twice every year, namely, at the solstices. The following results were obtained from the observations, by a process in which the burned volume was filled up and the increase in weight accurately measured:—

1. The heat of the sun for the half year between the June and the December solstice is greater than that for the half year between the December and the June solstice, but this difference is more marked at London (Board of Works) than at the Kew Observatory.
2. The annual value of the sun's heat is greater at Kew than at London in the proportion of 100 to 58.
3. The annual value of the sun's heat is peculiarly great about the period of maximum sunspots, but there are indications of a double heat-curve for one of sunspots, so that there is a subsidiary maximum of heat about the period of minimum sunspots.

On Supposed Sunspot Inequalities of Short Period, by Prof. Balfour Stewart and William Lant Carpenter, M.A.—Putting aside in the meantime the question of true or nearly apparent periodicity, the authors exhibited certain results obtained by this application of a method for detecting unknown inequalities in a mass of observations. This has been applied to thirty-six years' observations of sunspots, which have been divided into three series of twelve years each. Two apparent sunspot inequalities of about twenty-six days come out very prominently by this treatment, appearing for each of the twelve years in the same phase, and to very nearly the same extent. If the average value of sunspots for each year be reckoned = 1000, this is reduced to less than 900 at the minimum of the inequalities, and increased to more than 1100 at their maximum, so that the average range is more than one-fifth of the average value, a result of very considerable prominence.

Prof. Chandler Roberts read a paper *On the Rapid Diffusion of Molten Metals*. The two metals chosen were lead and gold inclosed in a letter U-shaped tube, the lead occupying the lower portion of the tube, and the gold being put in at the top of one limb. After about forty minutes Prof. Roberts found that the two metals had been thoroughly mixed.—Sir W. Thomson called attention to the extreme importance of this with reference to metallic alloys, and remarked that it resembled the diffusion of gases or of heat in a gas rather than of a solid in a liquid. Salt would take years to diffuse in a similar manner through water.

Mr. W. G. Black described a simple form of marine anemometer, in which the pressure of the wind on a sail of known area was registered by a spring balance. The sail could be easily placed in any required position on the ship, and set by means of a vane to the proper angle with the wind.—The arrangement was criticised by Prof. Hele Shaw, who described a form of his own which he had used for measuring water currents. This consisted of two light vanes, movable about the same vertical axis, and pressed outwards by a spring. The wind tended to make the vanes close up together, and their motion gave an indication of its velocity.

Papers on *The Standard of White Light*, and on *The Relation between Temperature and Radiation*, by Capt. Abney, and Sir C. W. Siemens respectively. Capt. Abney suggests as a high temperature standard an incandescent lamp. The light of this is compared by means of the spectrophotometer with that from Prof. Vernon Harcourt's standard lamp, afterwards described. The green light in the neighbourhood of E should be about one and a half times that of the gas standard, while the red light should be the same in the two. In a recent paper Capt. Abney criticised some of Sir W. Siemens's experiments of a similar nature. Sir William had used platinum wire in air instead of carbon in a vacuum, and the paper read was a reply.—In the discussion Dr. Schuster pointed out that a similar method, free from many of the difficulties under consideration, had been suggested by the late Prof. Clerk Maxwell, and apparatus for making the experiments was constructed by him shortly before his death.

Prof. Vernon Harcourt gave a description of a lamp for producing a standard light. It was arranged for burning air and the vapour of petroleum, mixed in the proportion of three cubic inches of vapour at a temperature of 60° F. to one cubic foot of air. The mixed gas is allowed to escape from a hole of a quarter of an inch in diameter, and burn in a flame two and a half inches high. Prof. Harcourt showed that the height of the flame was an index of the proportion in which the gases mixed, and was constant when the mixture remained constant.

Mr. E. P. Culverwell read a paper *On the Probable Explanation of the Effect of Oil in calming Waves in a Storm*. He said when the surface of the sea had become smooth after a storm it was very common for long rollers to break on a sandbar. If there were no wind and the sea was glassy, these would not break until quite close to the shore, even though the ordinary theory pointed to their breaking earlier, unless there was a force directed opposite to that of their motion. When exerted on the waves, such a force might be supplied by the wind; but if it rose in any direction the waves broke much sooner. This result was therefore due to some secondary effect produced by the wind pressure, and not directly by the pressure itself, and it was to the ripples produced on the surface, which disturbed the wave motion, that the speedy breaking was to be attributed. It was, however, a direct result of the theory that the ripples depended on surface tension for their propagation, and could not exist in large amount on the oiled surface. It was also evident that the hold of the wind on the wave was greatly decreased by the absence of ripples, and thus the oil acted both to prevent the wind having much effect on the surface, and also to modify the motion of the water in the wave.

Prof. Stokes read a paper by Dr. Huggins *On Coronal Photography without an Eclipse*. In a paper read before the Royal Society some time back, Dr. Huggins had shown that it was possible by isolating, by means of properly chosen absorbing media, the light of the sun in the violet part of the spectrum to obtain photographs of the sun surrounded by an appearance distinctly coronal in its nature. These researches have been continued, using a reflecting telescope by the late Mr. Lassell, and a film of silver chloride as the sensitive plate on which the photograph is taken. These plates are sensitive to the violet light only, and therefore it was unnecessary to use absorbing media which had proved a source of difficulty to sift the light. Fifty photographs in all were taken and examined afterwards by Mr. Wesley, who made drawings of them for the paper.—Dr. Ball, who was in the chair, examined some of the plates, and spoke of the interest and importance of this communication.

Prof. Schuster read a paper *On the Internal Constitution of the Sun*. He had calculated the volume of the sun from its mass, assuming that it consisted of a gas subject to gaseous laws and in the state of convectional equilibrium discussed by Sir William Thomson. The paper showed that, if the rates of the specific heats of the gas were less than 1·2, the volume of the sun would be immensely larger than at present, while, if greater than 2·0, the sun's volume would be far smaller than it is. The result that the rates of the specific heats must lie between 1·2 and 2·0 is so far in agreement with received theories of the constitution of the sun.

Notes on some recent Astronomical Experiments at High Elevations on the Andes, by Ralph Copeland.—These experiments were made during the first half of the present year at the cost of the Earl of Crawford. At La Puz, in Bolivia, 12,000 feet, with the full moon in the sky, ten stars were seen in the Pleiades with the naked eye, and also two stars in the head of the Bull that are not in Argelander's *Uranometria Nova*. The rainy season lasted roughly until the end of March, after which there was a large proportion of fine sky. At Puno, on Lake Titicaca, 12,600 feet, with a 6-inch telescope mounted on a lathe headstock, a number of small planetary nebulæ, and some stars with very remarkable spectra, were found by sweeping the southern part of the Milky Way with a prism on Prof. Pickering's plan. The most remarkable stars had spectra reduced almost to two lines, one near D, and the other beyond F, with a wave-length of 467 mm., and apparently identical with a line in *some* only of the northern nebulæ as observed by Mr. Lohse and Mr. Copeland. A few close double-stars were also found, amongst them β Muscæ.

At Vincocaya, 14,360 feet, the solar spectrum was examined with a somewhat damaged instrument. The chief fact noted was the relative brightness of the violet end of the spectrum. With a small spectroscope several lines were seen beyond H and H_2. The prominences were visible with almost equal facility in C, D_3, F, and H_8. Attempts to see the corona proved futile, nor were the prominences seen otherwise than in the spectroscope, the only difference being that the slit could be opened far wider than down at the sea-level. A most careful examination of the zodiacal light failed to show even the slightest suspicion of a line in its spectrum, which was continuous although short. Both at Puno and Vincocaya the air was very dry the relative humidity there and at Arequipa, 7700 feet, being as low as 20 per cent. At Vincocaya the black bulb at one time stood above the local boiling point, while the wet bulb was coated with ice. The author was of opinion that an observatory might be maintained without discomfort up to 12,000 feet, or even a little higher—the night temperature falling only slightly below the freezing point. At greater elevations the thermometer falls 1° for every 150 feet of height, the barometer sinking about 0·1 inch for the same change. At 15,000 feet it will thus be seen that arduous winter conditions are reached without any very material gain in the transparency of the atmosphere. From information received it seems possible to maintain a station for a short time in the early summer as high as 18,500 feet; later on the rains set in and render travelling very difficult. Railway and steamboat communication enable instruments of any size and weight to be carried as high as 14,660 feet, and as far as the Titicaca shore of Bolivia.

OUR ASTRONOMICAL COLUMN

Pons' Comet.—The following ephemeris is deduced from MM. Schulhof and Bossert's provisionally corrected elements:—

At Greenwich Midnight

1883.		R.A.			Decl.		Log. distance from	
		h.	m.	s.	°	′	Earth.	Sun.
Oct.	16	16	39	53	+55	37·7	0·2653	0·2723
	18	—	42	19	55	13·7		
	20	—	44	57	54	50·0	0·2520	0·2600
	22	—	47	47	54	26·5		
	24	—	50	48	54	3·3	0·2378	0·2472
	26	—	54	1	53	40·4		
	28	16	57	27	53	17·7	0·2226	0·2340
	30	17	1	5	52	55·3		
Nov.	1	—	4	56	52	33·1	0·2065	0·2204
	3	—	9	0	52	11·2		
	5	—	13	18	51	49·4	0·1894	0·2062
	7	—	17	49	51	27·6		
	9	—	22	37	51	5·9	0·1710	0·1916
	11	—	27	40	50	44·1		
	13	—	32	59	50	22·0	0·1513	0·1764
	15	—	38	35	49	59·6		
	17	—	44	29	49	36·8	0·1303	0·1607
	19	—	50	42	49	13·4		
	21	17	57	16	+48	49·1	0·1079	0·1445

The intensity of light will be three times greater on November 21 than on October 16, and will increase until near the middle of January. According to the experience of 1812, we might expect it to draw within naked-eye vision at the beginning of December, but it is not likely to attain a brightness at all comparable with the conspicuous comets of the last few years. It may rather be anticipated that when best seen, its light will be nearly that of stars of the third magnitude. We are of course assuming the comet not to have undergone material change since its last appearance. On the morning of August 18, 1812, the Paris astronomers have the note:—"La comète commence à être visible à l'œil nu; son noyau assez brillant, est enveloppé d'une chevulure et sa queue est d'environ 1½° à 2°." Employing MM. Schulhof and Bossert's final orbit, we find that at the hour of observation, about 2h. 30m. a.m. G.M.T., the comet was in R.A. 114° 24′, Decl. +40° 27′, distant from the earth 1·4713, and from the sun 0·9449, so that the intensity of light, expressed in the usual way, would be 0·52, which corresponds to that on December 1 in the present year. On the morning of September 14 it was remarked:—"La queue de la comète est divisée en deux branches parallèles; sa longueur paraît d'environ 3 degrès." At 4h. 30m. a.m. G.M.T. the comet was distant from the earth 1·2324, and from the sun 0·7778, whence, the earth's radius-vector being 1·0051, the angle at the comet was 54° 29′, and with Newcomb's solar parallax, the real length of the tail, if extending as most usual in the direction opposite to the sun, would be 7,600,000 miles, or a little over.

In announcing the discovery of this comet by Pons at Marseilles on July 20, 1812, Zach remarked (*Monatliche Correspondenz*, xxvi. 270) that it was the sixteenth (? fourteenth) comet which he had independently discovered within ten years. So indefatigable a worker in this direction well deserves that his name should be permanently associated with at least one of his discoveries, and none presents itself as affording a more fitting case than the comet of 1812.

Swift's Cometary Object.—It would appear from unsuccessful search at European and American observatories that Mr. Swift must have been mistaken in supposing he had observed a comet in the places published in *Astron. Nach.*, No. 2541.

The Cordoba Observatory.—Dr. B. A. Gould, director of the Observatory at Cordoba, passed through London last week *en route* for South America, after attending the meeting of the "Astronomisches Gesellschaft" at Vienna, and that of the International Standard Commission at Paris. We learn from Dr. Gould that the printing of the second volume of Cordoba Zones is nearly completed in London. The attention of this